The Impact of System Configuration on Device Radiation Damage Testing of Optical Components

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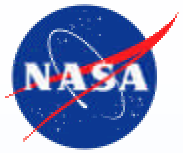
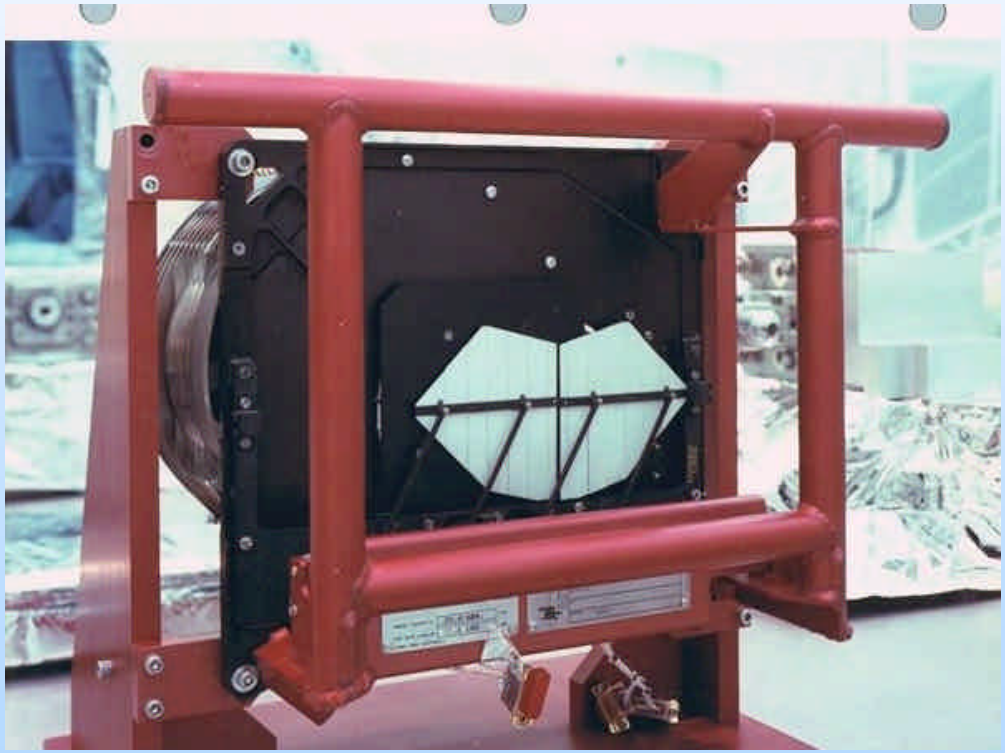


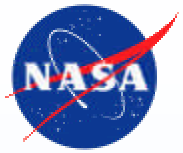
Outline

- **Wide Field/Planetary Camera 2 (WF/PC 2) Mission and Background**
- **Operational Anomaly in LED – PT Encoder**
- **Investigation**
  - **Background: Typical LED – PT pair assembly**
  - **Paradox: How does a radiation tested pair of parts fail?**
  - **Hypothesis: Tests did not reflect application**
  - **New Test Results**
- **Anomaly Resolution**
- **Lessons Learned**

What is WF/PC 2?

- **WF/PC 2 is a CCD based imager aboard Hubble Space Telescope**
- **WF/PC 2 is the second generation wide field planetary camera**





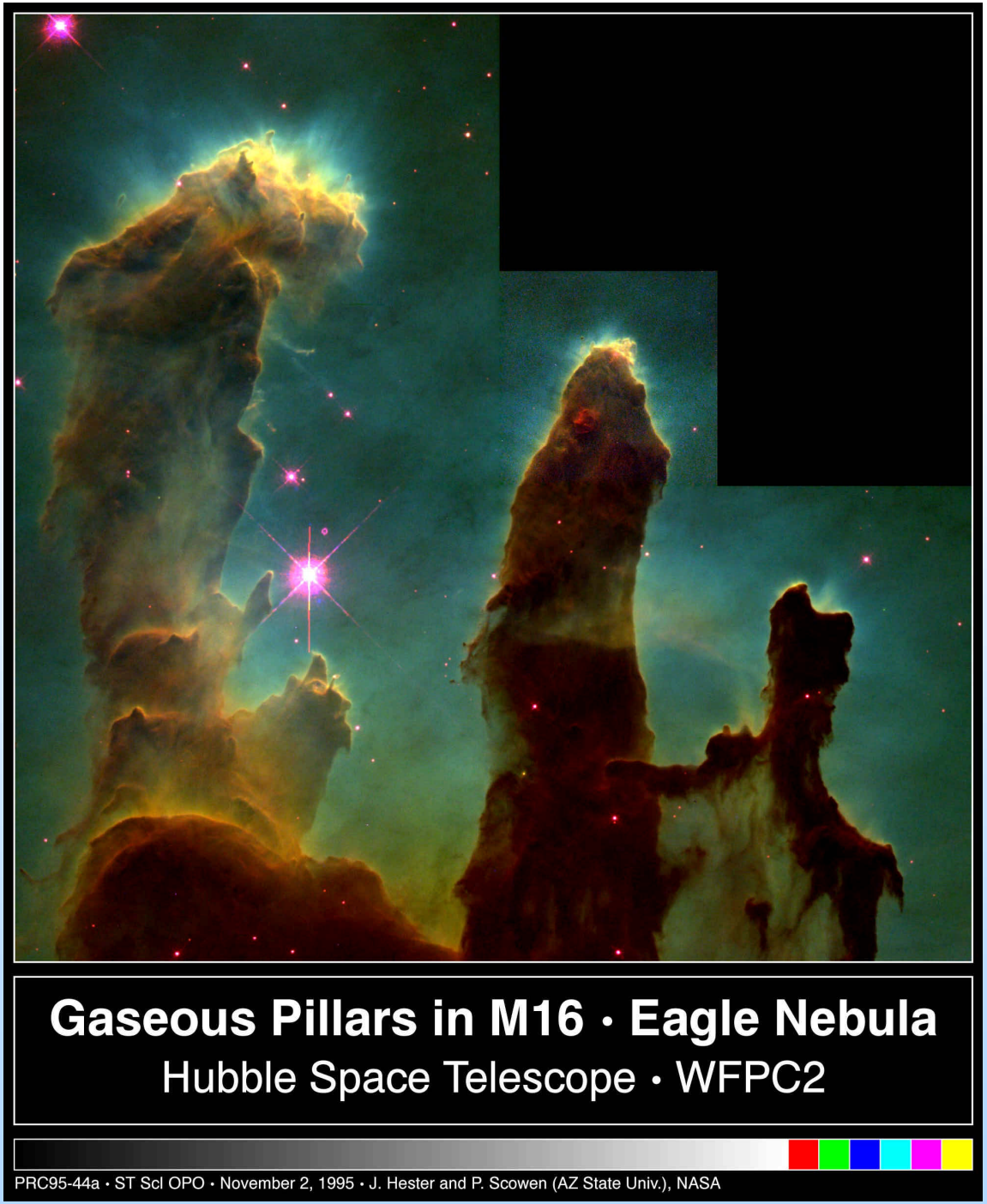
WF/PC 2 History

- WF/PC 2 was the “workhorse” camera from December 1993 to March 2002
- “Replaced” as the primary camera by the Advanced Camera for Surveys on SM3B but WF/PC 2 is still operational for science gathering
- WF/PC 2 will be replaced by WFC 3 on SM4

What Does WF/PC 2 Do?

- Investigate the composition, physical characteristics, and dynamics of celestial bodies
- Examine the formation, structure, and evolution of stars and galaxies
- Study the history and evolution of the universe
- Provide long-term space-based research facility for optical astronomy

Camera	2-D imaging photometer
Spectral Range	1150Å to 10500Å Near UV to Near IR
Image	150” x 150” L-shaped field (0.1”/pixel)
	Simultaneous with 34”x 34” square field (0.046”/pixel)
Spectral Filters	48 total
Faint Targets	Limited by sky background (broad filters) or noise in readout electronics (narrow & UV filters) with RMS of 5 detected photons
Saturation	>53,000 detected photons/pixel (no safety issues)



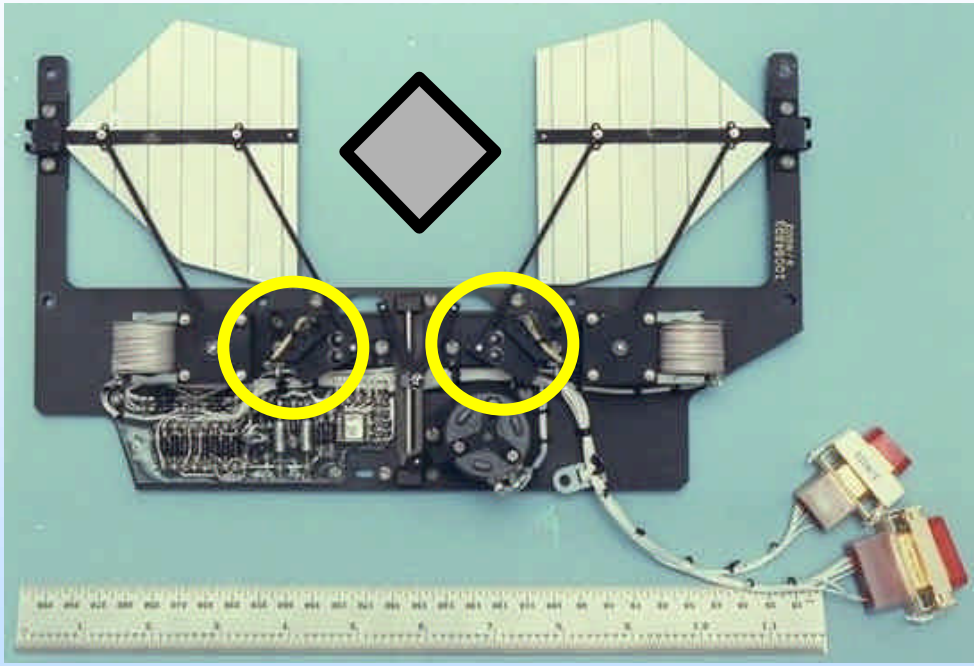
Gaseous Pillars in M16 · Eagle Nebula

Hubble Space Telescope · WFPC2

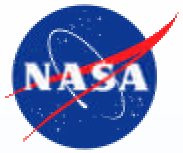
PRC95-44a · ST ScI OPO · November 2, 1995 · J. Hester and P. Scowen (AZ State Univ.), NASA

The Nature of the Anomaly

- In the summer and fall of 2000, two anomalies in the read out of the shutter position encoders of WF/PC 2 forced the instrument into safe mode
- The encoders each consist of an LED – PT pair



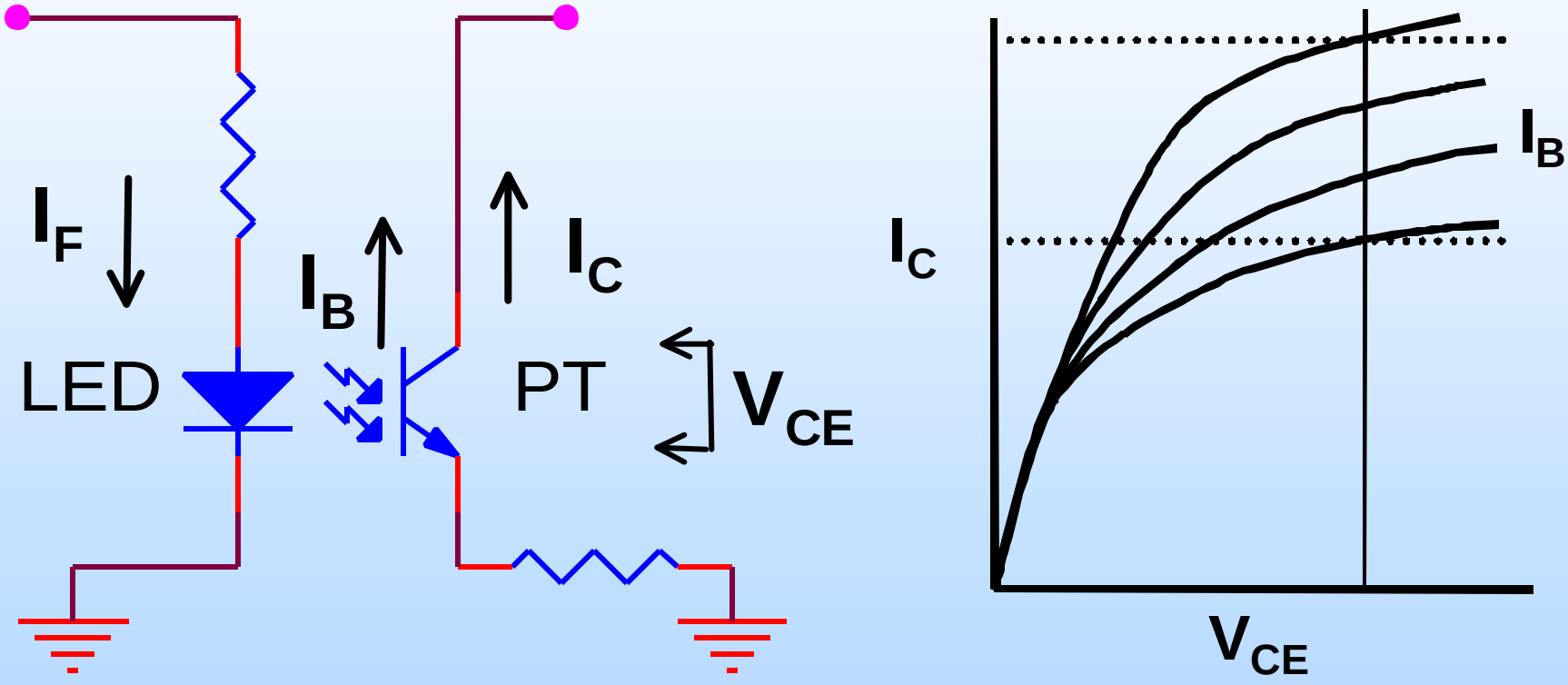
- 7 years into a 5 year mission in an orbit of 28.5° at 598km
- Both shutters read as “closed”
- Further investigation of telemetry indicated 10 total errors over the 9 week period



Anomaly Investigation

- **Anomaly Review Board initially identified 12 possible faults**
  - **8 mechanical faults were ruled out by analysis of flight telemetry**
  - **2 electrical faults ruled out by flight telemetry**
- **All that remained:**
  - **Anomalous behavior of the LED**
  - **Anomalous behavior of the PT**

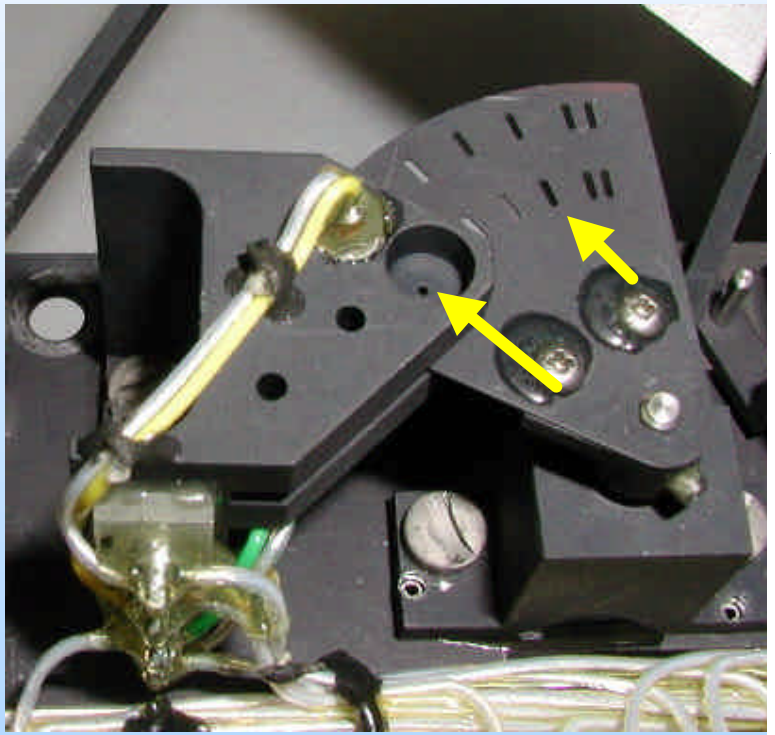
Typical LED – PT Pair Assembly and a Paradox

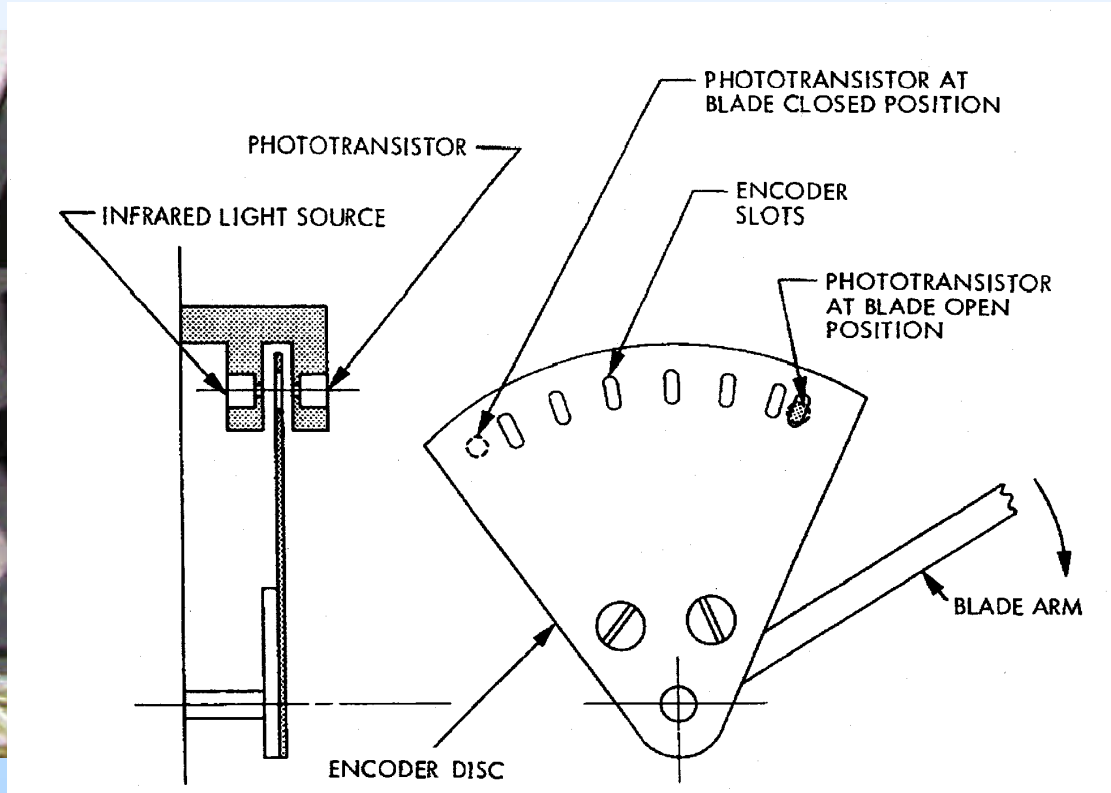


- How does a radiation characterized pair fail?

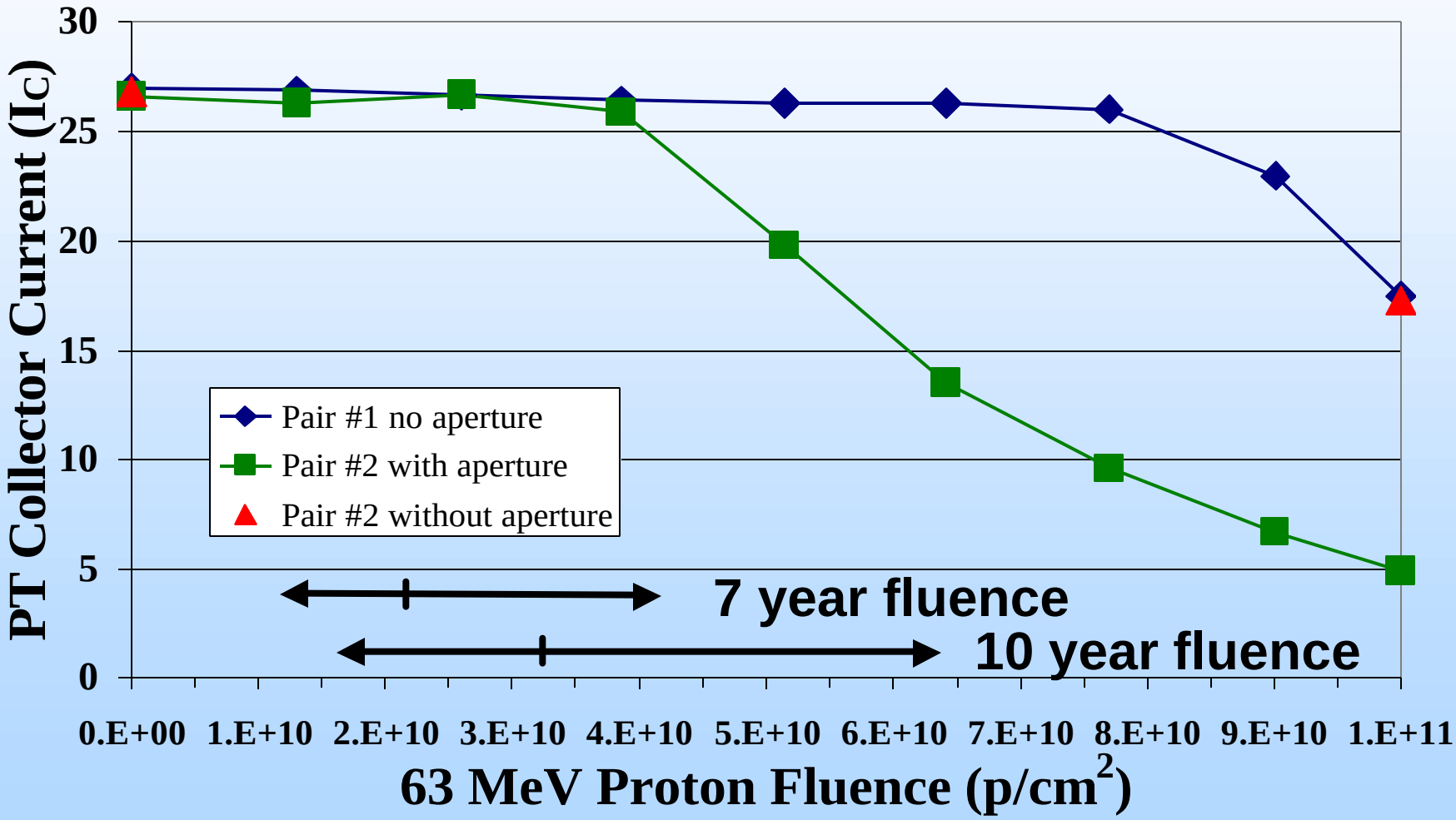
New Hypothesis: Testing Fidelity

The test conditions did not accurately reflect the application.

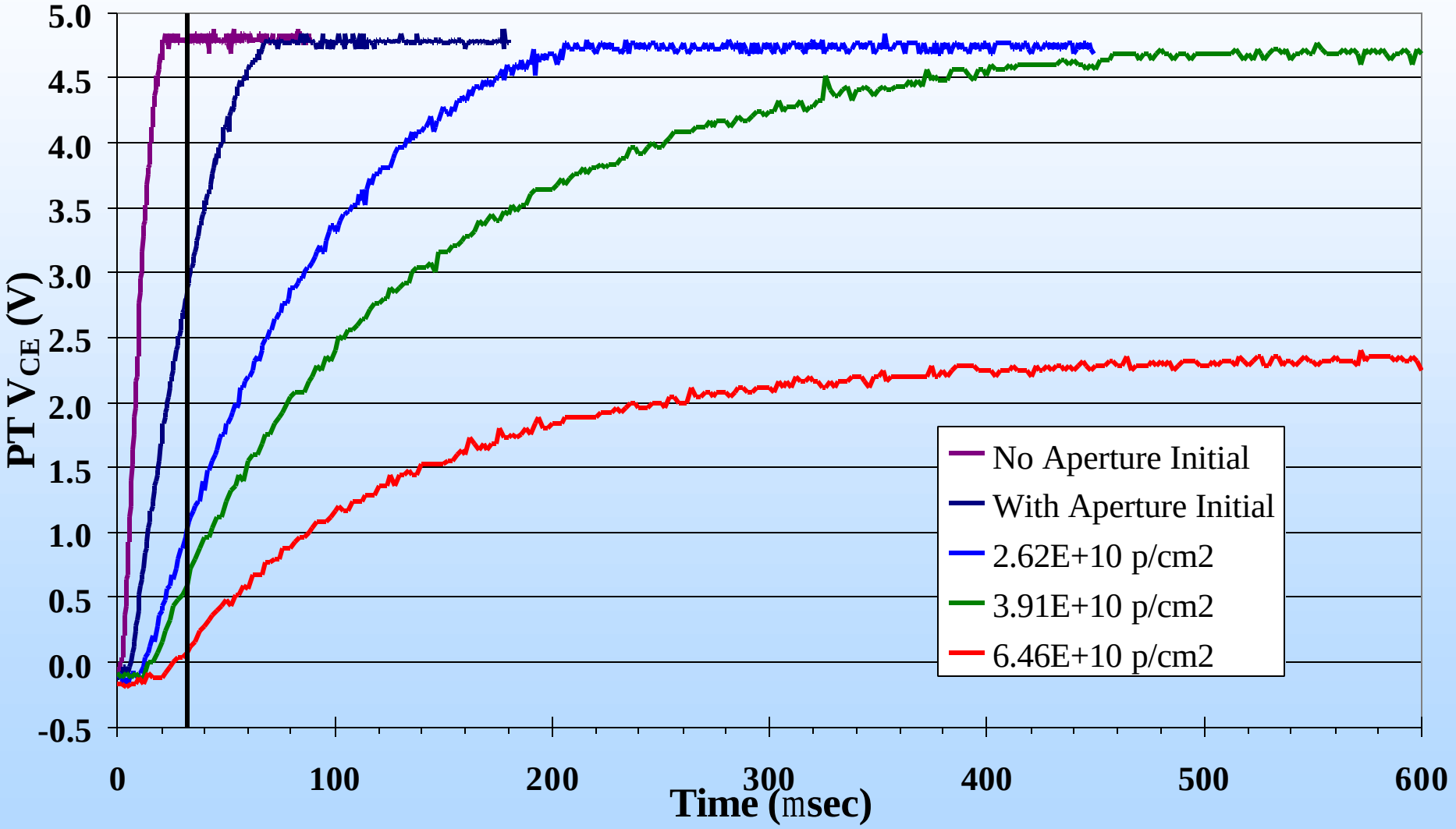


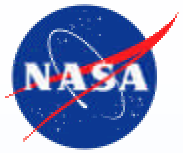


PT Retest Results: Output Current (I_C) Degradation



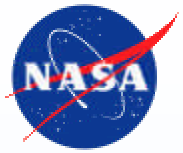
Pair #2 Retest Results: V_{CE} & Rise Time





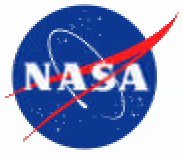
What does it all mean?

- In addition to the anticipated radiation degradation, the application degraded the operation of the LED – PT pair in a surprising way
- The combined effects of radiation and mechanical configuration lead to an unpredicted failure



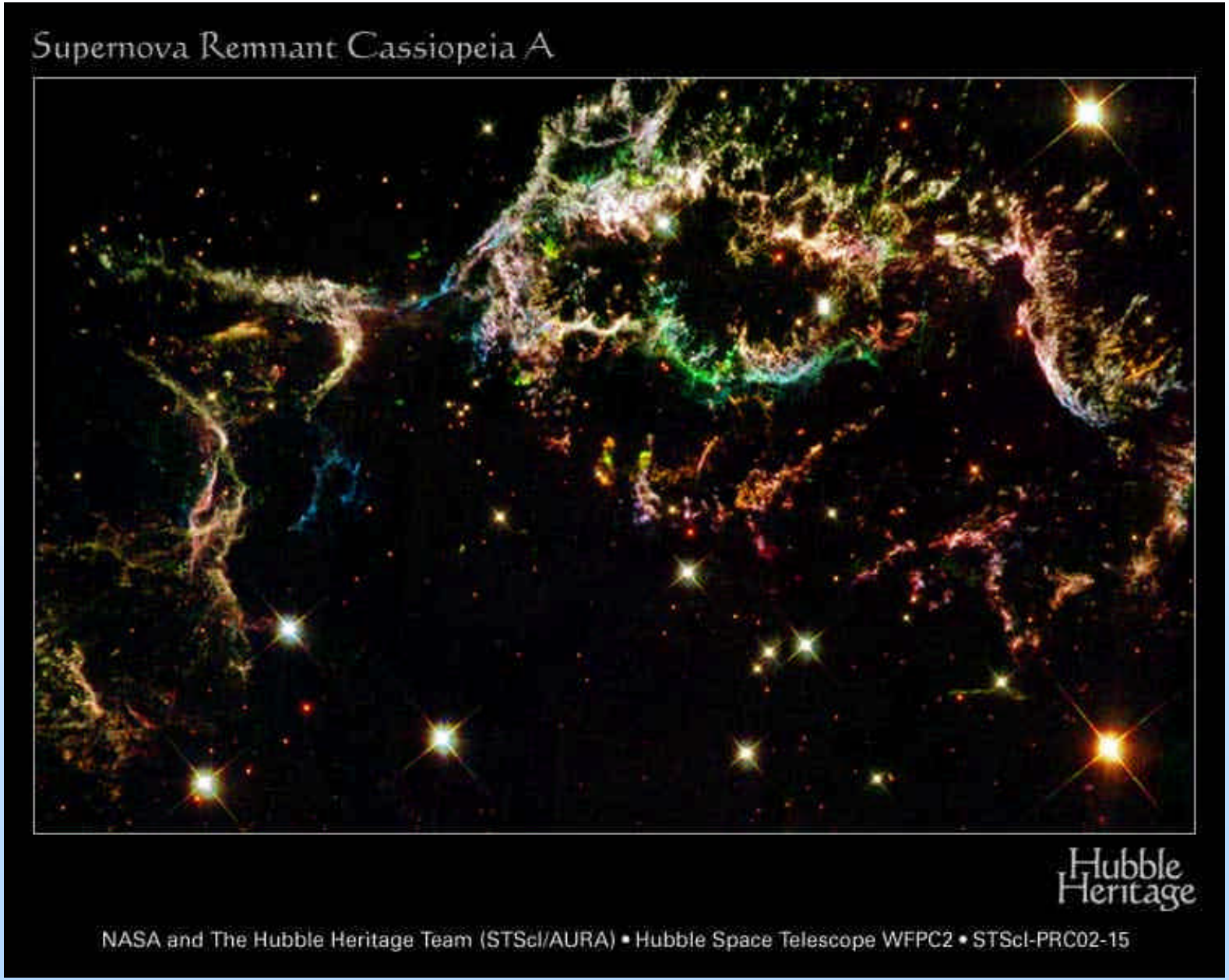
Resolution of the Anomaly

- To correct the anomaly, a RAM patch was sent to the WF/PC 2 microprocessor to sample the PT after 10ms to ensure there was sufficient time to ramp up the PT
- No more anomalies



Lessons Learned

- **Application specific configuration will affect in-flight performance and ground based test results**
- **In addition to defining typical electrical performance, understanding the mechanical, thermal, and other physical conditions must be known in order to ensure test fidelity**
- **Close communication between the test engineers and *all* areas of the project is necessary to ensure appropriate radiation testing is conducted**
- **Not only must you fly what you test and test what you fly – you must also test the *way* you fly it**


Supernova Remnant Cassiopeia A
Hubble Heritage
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